Determining The Correct Fuse Size for your DC/DC Converter

Fuses are required on the input to your system to prevent catastrophic system failure if the DC/DC can no longer protect itself from overload conditions. Most CALEX DC/DC converters are protected from shorts to common by either short circuit current limiting and/or thermal overloading circuits. The specific data sheets spell out the methods used. The fuse, therefore, is required in case of a DC/DC converter failure that it cannot correct, as in the case of a serious converter failure that causes a short on the input. While these types of problems are rare with CALEX DC/DC converters, Murphy's law suggests they will happen just when they are least anticipated or are very costly to fix.

It is cheaper to replace a DC/DC converter and a fuse than your entire system PCB and a DC/DC converter. With CALEX's 5 year warranty, chances are that you will only be paying for the fuse. CALEX will automatically replace the converter if it fails due to manufacturing defect.

Determining the correct fuse size for a DC/DC converter requires several considerations to prevent premature fuse failure in the field.

The first consideration is the steady state current drain. Most larger DC/DC converters are constant power devices, that is, they must increase current drain as the input voltage drops to maintain the constant power relationship. A curve of this phenomena is shown on the data sheet. The fuse must be sized large enough so that it will not blow out under steady state conditions. Usually this means sizing the fuse at 150% to 200% percent of the maximum steady state input current at maximum load and minimum line input voltage.

Refer to the specific DC/DC converter's data sheet for a graph of the steady state input power requirements. These curves are usually run at 50% and 100% power on the output so you can make an informed decision.

The second consideration may be the most important one, the transient or start-up current. When the input voltage is initially connected to the input of any DC/DC converter, the input bulk capacitors must be charged. The current into the input terminals of a DC/DC converter is approximately $I=V/R$ for input rise times less than 10 milliseconds or so. V is the input voltage change and R is the wiring resistance, your sources resistance under start-up and the ESR of the converter's input bulk capacitors.

One rule of thumb can be used here: The bigger the DC/DC converter, the larger the inrush current! This is because larger, lower ESR capacitors are used inside the converter. This inrush current can have a significant effect on the fuse's life, especially for converters that are switched ON and OFF frequently.

For a 50 watt, 48 volt DC/DC converter, this inrush current can approach 100 amps if the input is switched instantaneously and your source can supply it. While this instant input switching and that big of an input source is unlikely in practice, it could happen. A small 2" x 2" converter might only produce a 5 or 6 amp surge under these conditions.

The LC input filter does very little to dampen these fast transitions because these filters were sized for normal operation with 20 to 50% overload capability. During a fast start-up transient, these filters effectively saturate, shorting their inductance to a small value and removing them from the circuit. If we sized the input filters to handle the inrush transient, the filters would be bigger than the converter.

Slow blow fuses are the best choice to use because they have larger inrush current capability. That is, they can withstand the repeated inrush current demands longer than an equivalent fast blow fuse.

The circuit that our DC/DC is driving can also have different current demands when it is starting up, either less or more than the steady state value.

Every system is different in nature and it is impossible for us to know before hand just what your system is like or what your system requirements are. For example, telecommunications equipment is very different from a medical instrument. While telecommunications equipment is usually powered and may undergo very few ON/OFF cycles during its lifetime, the medical instrument may be turned ON and OFF hourly.

It is possible to run a life test on your system to determine if your proposed fuse size is capable of handling the long term effects of inrush current. At CALEX, we perform the worst case fuse test on our products that simulate thousands of ON/OFF cycles to be sure that our fuses don't fail prematurely.

Test, Test and Then Test Some More

The answer to picking the correct fuse is to test your circuit thoroughly and determine the fuse required for your particular system.

At CALEX, the fuse life test is run as follows: connect the DC/DC to your actual loads then cycle your system ON and OFF for as many cycles as you think it should survive plus whatever cushion your specifications dictate. If several fuses survive this, then you can be comfortable that you are probably OK. You might even find out that other parts of your system don't stand up under this testing.

If it is not practical to cycle your entire system ON and OFF, then you can use a relay or power MOSFET driven by a simple 555 type of timer circuit and battery set at ½ Hz or so. This type of arrangement gives 1800 cycles per hour, so testing goes quickly.

Be sure that the inrush current that is produced by the relay or switch is like your actual systems by inserting a resistor in series with the switch to limit the peak current to what your system actually produces. Also be sure that your source can be cycled this rapidly without overheating or otherwise sustaining damage. This means that you should remain present during the testing to be sure that things don't get out of hand!

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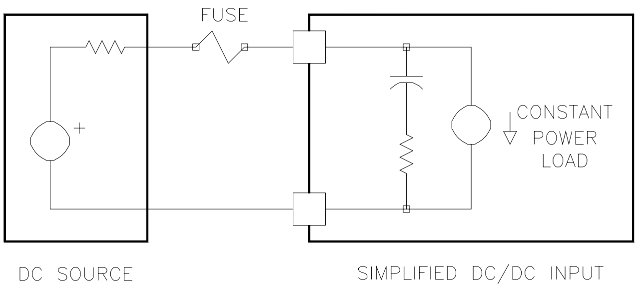

Figure 1.
The ratio of inrush current to steady state current can be 10 or 100:1 in some systems. Picking the correct fuse requires knowing something about your system's use and testing.

Conclusion

Remember that the fuse is used as catastrophic converter protection in most cases. Again, refer to the specific data sheet for exact details. Also remember that the purpose of the fuse is to fail if the input to the DC/DC becomes shorted so be sure that you don't pick a fuse bigger than your system's source can blow.

Make an informed fuse choice, then test your choice to see if it meets your system requirements for life and protection. If your source is so small that it can't cause damage to your PCB's even if the DC/DC is shorted you may actually be able to forego the fuse altogether, but be sure to check with UL or other regulatory agencies that you have to deal with first to get their views on the matter.

Also remember that slow blowing fuses usually have more tolerance to inrush currents than an equivalent fast blow fuse, hence we recommend slow blow fuses for all DC/DC input protection applications.